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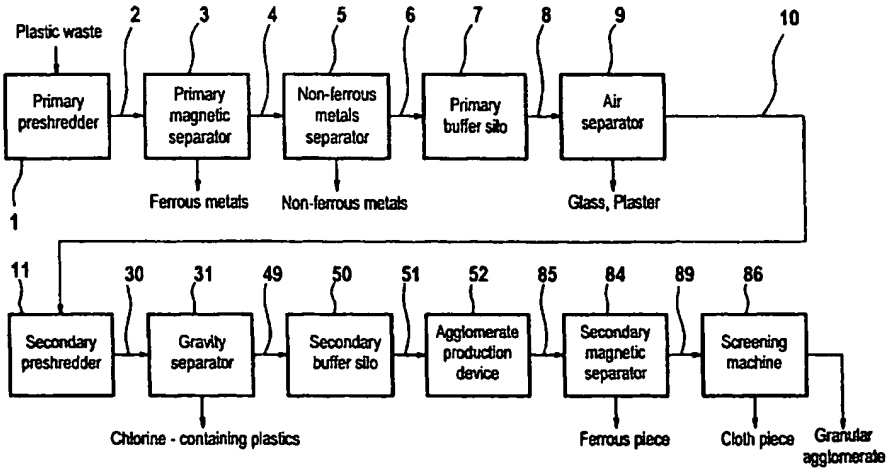

(57) Abstract: The invention relates to a method and an apparatus for dry treatment of plastic waste containing plastic materials of different specific gravity and of different shape, in particular containing a proportion of flat and/or band-like film materials. The plastic waste is shredded in a first shredding step, separated from metal materials in a first metal separating step and again shredded in a second shredding step. The plastic waste is conveyed from the first shredding step to the first metal separating step and from the first metal separating step to the second shredding step with conveying systems in which rotating components are encapsulated against their environment. The plastic waste shredded in the second shredding step is separated from chlorine-containing plastics and then converted into plastic agglomerate in an agglomerating step where the plastic waste is mechanically precompacted and then thermally agglomerated. Finally the plastic agglomerate is separated from metalized or magnetized film or band-like materials. Byselecting an appropriate conveying technique and agglomeration technique, a final product of high quality can be obtained.

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METHOD AND APPARATUS FOR TREATMENT OF PLASTIC WASTE

Technical Field

The invention relates to a method and an apparatus for dry treatment of plastic waste, which is suitable especially for converting domestic plastic waste which includes a substantial proportion of flat and band-like film material into granular agglomerate that can be recycled.

Background Art

It is desired that the plastic waste exhausted by each household will be recycled in view of effective utilization of resources. The domestic plastic waste comprises various kinds of plastics with full variety in their shapes. The standards for municipal solid waste collection differ from country to country. In Germany, a nation wide collection network was established, involving both curbside collection (for plastics and metals) and dropoff igloos (for glass and paper). Further, the material from the so called "yellow bags" is pre-sorted prior to the treatment, so that for example EPS (Expanded Polystyrene) is removed as a separate fraction. This is different from systems in other countries, for example in Japan.

It has turned out that the municipal solid waste in Japan comprises a proportion of audio and video cassettes, which is remarkably higher than that in Germany. Audio and video tapes consist of metal coated bands or strips made of very thin PET (Polyethylene terephthalate). They show magnetic behaviour and can be separated easily by means of a drum magnetic separator, once they have been cut down to a size of less than 20 mm. Further in contrast, even though the collection bags have not been manually sorted or automatically pre-sorted, the proportion of metals, in particular tin plate and aluminium, is considerably lower than in the German "monofraction". In a visual evaluation of the material, it will be noticed that the proportion of EPS is high, since it is not sorted out. Even though a careful pre-sorting may assist in the further treatment of the waste, said waste includes impurities such as e.g. metals, glasses, plasters, clothes, papers. Some of the foreign substances are bound to plastic materials.

A high content of flat and band-like film material and foams requires adaptation of the waste treatment techniques.

Usually, the waste, also including audio cassettes and video cassettes, is shredded in a first shredding step and screened, where the mesh diameter is from 40 to 100 mm or even larger. In this first shredding step, the casings of the audio and video cassettes are broken, and the reeled magnetic tapes leave the shredder as a compact unit through the screen holes. It has now turned out that during conveying these tapes unwind rapidly and come into contact with rotating shafts which are components of many conveying aggregates, for example scraper chain conveyors or chain conveyors with pipe casings. This means that the shafts of reversing stations of the conveying aggregates wind up the tapes with the consequence that they cannot fulfil their task of reversing the chain elements. Finally, the chains may jump away from their guides, and the conveyor does no longer operate or is even damaged. Another consequence from winding up the tapes on the shafts is that the conveying resistance increases to an extent that the drive devices of the chain conveyors will be strained too much. It may even be the case that the tapes enter into the shaftbearings, since for example conveyor belts press into the edge regions of the shaft. The bearings are heated by the thus increased frictional resistance and are destroyed.

Various methods and apparatus are already known for treatment of plastic waste. For example, EP 0 800 445 A1 describes a method for treatment of plastic waste wherein the waste is shredded and then separated from ferrous materials with a magnetic separator and from heavy plastics such as e.g. hard polyvinyl chloride (PVC) with an air separator. Thereafter, the residual plastics are thermally agglomerated or compacted under pressure. During the agglomeration process scatterable substances, such as e.g. steam, glass fiber and paper, are sucked off through suction devices. The generated agglomerate is shredded in a grinder to a particle size less than 8 mm.

US 5,522,554 describes another method for treatment of plastic waste wherein the plastic waste is shredded in a first shredding step and then separated from ferrous materials with a magnetic separator and from non-ferrous metals with an electrostatic separator and shredded again in a second shredding step. The plastic waste shredded in the second step is agglomerated with a friction force and then shredded again.

A further problem with audio and video tapes is the high melting point of PET. The temperatures in an agglomeration process are typically in the range from 100 °C to 140 °C, therefore far below the softening temperature of PET of about 240 °C. This has as a consequence that the PET tapes are not bound into the agglomerate and remain present as uncompacted fluffy material. They

reduce thus the final agglomerate density and decrease its pourability, so that such agglomerate cannot be effectively used in the steel industry and in the petrochemical industry.

Also a relatively high proportion of EPS has consequences, since they adversely affect the efficiency of an agglomerator, since the filling volume can, under most circumstances, be not effectively used.

The problem of PVC separation has been addressed above. For many applications, in particular when treated plastic waste should be used as a fuel in the steel or petrochemical industry, PVC is absolutely detrimental, since it is not only responsible for increased corrosion, but creates also the risk that hazardous substances, such as dioxin and furanes, are produced.

NKK News, volume 38, December 1998, disclose in their release "1. NKK to Expand Waste Plastics Recycling For Blast Furnace Feed" a waste plastics recycling system flow where municipal and industrial waste plastics are supplied to a primary crusher, a ballistic separator, magnetic and wind-powered waste sorters, a secondary crusher, a PVC separation and removal system, a granulator and a storage silo. For the PVC separation a centrifugal system of wet type is used. The granulator sizes the PVC free plastics material in order to bring it into a condition to be blown into a blast furnace.

It has turned out that hard PVC plastics can be effectively separated in this way.

Domestic plastic waste contains chlorine-containing plastic materials not only as hard chips or the like, but also as film-like material which had been used in particular for packing sensitive foods to protect them against ambient oxygen. These film-like materials cannot treated by the above centrifugal system.

In order to deal with this problem, the document JP 10 258 428 A discloses another wet type separation apparatus, again using the specific gravity difference of PE, PP, PVC and others. At first, hard plastics, for example bottles, and film-like plastics are sorted by a windforce sorter. The film-like plastic is then fed to a crusher to be crushed to a particle size of 20 mm or less. The crushed plastic is sent to a vertical specific gravity separation and the light fraction is recovered as a floating component.

In the past years it has turned out that wet procedures are too costly in an efficient waste recycling process. The method described in EP 0 800 445 A1 which forms a basis for the waste treatment is a dry process where practically no water is added to separate the components of the waste from one another. It would therefore be highly desirable to continue this successful route and to provide a method and an apparatus for treatment of plastic waste in which the chlorine-containing plastics can be removed without having a wet separation step.

US 5,042,725 discloses to separate polyvinyl chloride from lighter foam particles by using a vibrating table wherein an airflow levitates the less dense foam particles and blows them off and the PVC particles setting at the bottom of a vibrating screen. A destaticiser sprays a suitable agent on the mixed vinyl and urethane particles to remove static charge therefrom. Film particles are removed by electrostatically charging them again, so that they can be separated.

The document JP 10 225 931 A proposes to use a board which can vibrate horizontally in specified vibration direction, wherein a blowing unit blows an air stream form below the board. The board is inclined in the specified vibration direction at an inclination angle and further inclined in the horizontal direction perpendicular to the vibration direction as a second inclination angle. Battle plates are arranged on the board in parallel to the vibration direction. Therewith, PVC and PVDC films can be separated from waste plastics with high efficiency. A similar dry separating device is disclosed in JP 10 314 675 A, JP 10 225 932 A, JP 09 216 226 A or JP 01 001 192 where a tilting rotary board is used.

It is the object of the invention to provide a method and an apparatus for dry treatment of plastic waste which is specifically adapted to the problems of plastic waste containing substantial proportions of flat and/or band-like film materials, such as audio and video tapes.

This object is achieved with the method of claim 1.

According to the invention, a plastic waste treatment method comprises a first shredding step of shredding a mass of plastic waste containing plastic materials of different specific gravity and of different shape, in particular also film-like materials, a metal separating step of separating metal materials from said plastic waste thus shredded, a second shredding step of shredding said plastic waste from which said metal materials have been separated down to a size of not more than 20 mm. It has already been mentioned that audio and video tapes can easily be removed by means

of a drum magnetic separator once they have been cut down to such a size. The second shredding step is essential. If the waste material would have been cut down to a size of 20 mm already in the first shredding step, the shredder would be easily destroyed through hard metal contaminations which have to be removed before fine shredding. Since the long tapes are therefore present in a system until leaving the second shredder, the invention is characterized in that the plastic waste is conveyed from the first shredding step to the metal separating step and from the metal separating step to the second shredding step with conveying systems in which rotating components are encapsulated against their environment. Still according to the invention, an agglomerating step is provided of formerly agglomerating said plastic waste thus obtained, where said plastic waste is mechanically precompacted substantially without increasing its temperature prior to the thermal agglomeration. So the fluffiness of film materials can be reduced, and even foams may be precompressed. The invention provides also for a second metal separating step, in particular of separating metalized or magnetized film or tape materials, which have not been agglomerated. During this step, also smaller metal particles can be removed, such as steel balls or the like which form part of spray nozzles of plastic detergent bottles. By selecting an appropriate conveying technique and agglomeration technique, a final product of high quality can be obtained.

"Agglomeration" in this respect means that the plastic material is heated above the softening temperature of the plastic material, but below its melting point. Therefore, a surface effect occurs, so that the single particles adhere to one another and form agglomerate having high specific surface. It is special for agglomerating plastic materials that some methods which work with high pressure support formation of agglomerates. These are disk compactors and pelletizers. Only the pot agglomerator works approximately at atmospheric pressure.

It has turned out that pot agglomerators which have been preferred until now because of their simple construction are not appropriate, if high proportions of EPS and fluffy materials are contained in the waste plastic, because of the practically pressureless agglomeration which does not effectively use the filling volume of the pot. Also pelletizers have disadvantages, since the space between rollers and dye is limited, and no precompacting can occur. Therefore, it is preferred to use a disk compactor where the supplied waste plastic is precompacted by means of a feeding screw. By this precompacting, high processing rates are achieved, concomitantly with a satisfying degree of agglomeration. It has turned out that pouring density of 320 to 550 kg/m^3 can be

achieved. This is in particular important for a use of the agglomerate as fuel in the steel and petrochemical industry.

If a proportion of PVC is remarkable, the invention in a preferred embodiment provides for a plastic separating step of separating chlorine-containing plastic materials from said plastic waste shredded in said second shredding step, preferably by making use of differences in specific gravity among said plastic materials of different kinds contained in said plastic waste, and optionally a waste screening step of screening said plastic waste from which said chlorine-containing plastic materials have been separated, to achieve at a pourable bulk material, where the plastic separating step comprises the steps of supplying said plastic waste on a slant board, supplying air to said plastic waste through a plurality of penetrant holes provided in said board in the direction from under to over said board with a velocity and volume rate that said chlorine-containing plastic materials accumulate in a layer adjacent said slant board and plastic material having lower specific gravity than said chlorine-containing material accumulate in a layer floating on said layer of chlorine-containing material, and applying, in such a state, a vibration exciting force to said board to convey said chlorine-containing materials into a direction substantially upward said slant board and to convey said layer of plastic materials having lower specific gravity into a direction substantially downward said slant board.

Since the plastic waste after the second shredding is fine, the degree of size heterogeneity of the plastics is low and hence the effect of the size heterogeneity on separation of the chlorine-containing plastics is weak. As a result, the chlorine-containing plastics can be separated from the other plastics making use of the differences in their physical properties such as e.g. a specific gravity. So the separation efficiency of the chlorine-containing plastics from the plastic waste can be improved remarkably.

The invention in this embodiment is based on the recognition that the size of the plastic waste has a significant effect even on the separation of the chlorine-containing plastics in the dry processing of waste. It has been found the separation efficiency of the chlorine-containing plastics whose specific gravity is a little higher than of the other plastics will improve with the decrease of the size heterogeneity.

The separation of the chlorine-containing plastics making use of the difference in specific gravity is achieved with a slant board (e.g. a tilting table) which, therefore, is inclined in one direction

only. The plastic waste is supplied on the board and is exposed to upward air stream through a plurality of penetrant holes provided in the board in the direction from under to over of the board. In such a state, the plastic waste is exposed to acceleration due to a vibration exciting force applied to the board. By selecting the velocity and the volume rate of the air stream through the holes, it can be achieved that the plastics whose specific gravity is lower move up on the chlorine-containing plastics, so that they are practically separated into layers which float upon another. Under this condition, owing to acceleration due to vibration of the board, chlorine-containing plastics whose specific gravity is higher go up along the slope of the board, while the other plastics whose specific gravity is lower go down along the slope. Hence the separation efficiency of the chlorine-containing plastics becomes high.

In a preferred embodiment of the invention, the plastic waste contacts ionized air in the chlorine-containing plastics separating step.

By the contact of the plastic waste with ionized air, any static charge in the waste is neutralized, so that as a result the plastic waste particles do not stick to one another. This is in particular useful when the plastic waste contains film-like plastic material.

In another preferred embodiment of the invention, fluffy uncompacted material is separated from a flow of agglomerate obtained by agglomeration of the plastic waste, and this fluffy uncompacted materials is agglomerated again together with the plastic waste free of the chlorine-containing plastic materials. Also small amounts of scatterable materials are still in the process.

"Scatterable materials" are ashes, cloth fibers, paper fibers and the like which are contaminants in an agglomeration process.

"Fluffy uncompacted material" means plastics which was not agglomerated although it should be agglomerated.

Thus, the agglomerate which will finally leave the line can be protected against mixing with any unagglomerated material. The ratio of the unagglomerated material to the agglomerate is significant e.g. at the beginning of operation. Since the fluffy uncompacted material is recovered to be agglomerated again, there is practically no loss of usable material.

In still another preferred embodiment of the invention, the generated agglomerate is shredded in the third shredding step during cooling with a mixture of air and water by evaporating water after having contact with the agglomerated material. Thus, the temperature of agglomerate becomes lower and the agglomerate is shredded easily.

A further preferred embodiment of the invention provides that the plastic waste exiting from the agglomeration device is conveyed by a low pressure into a cyclone device, where the low pressure generating device is located on the clean side of the cyclone device. The suction device generating the low pressure is placed downstream the cyclone, the agglomerate and scatterable substance do not pass through the suction device while only air passes through it. As a result, wear, due to the agglomerate, of the suction device can be avoided, and a considerable noise reduction will be obtained. Finally, compared to the arrangement that the suction device is in the material flow, energy can be saved, since the gap between the rotor blades and the casing can be kept small, and low pressure can be maintained effectively. Another important result is that clean air will leave the apparatus, since any contaminant material is recycled until is has been included into the agglomerate or has been screened out.

Brief Description of Drawings

Figure 1 shows an embodiment of the apparatus according to the invention using a flow chart.

Figure 2 shows an embodiment of the secondary preshredder for use in the apparatus in a vertical sectional plane.

Figure 3 shows an embodiment of the gravity separator for use in the apparatus in a vertical sectional plane

Figure 4 shows an embodiment of the agglomerate production device for use in the apparatus represented as a flow chart.

Best Mode for Carrying Out the Invention

A preferred embodiment of the apparatus for treatment of plastic waste according to the invention will now be explained with reference to Figures 1-4. The apparatus comprises a primary preshredder 1 which is connected to the primary magnetic separator 3 by a conveyor 2 in which

all rotating parts have been encapsulated from their environment. This encapsulating can also be achieved by a conveyor belt having rubber sealing along the conveying belt. Such types of conveyors will in the following be referred to as "closed conveyors". It can also be thought of pneumatic conveyors, even though not preferred here. The primary magnetic separator 3 is connected to a non-ferrous metals separator 5 by a chute 4 of the primary magnetic separator 3. A closed conveyor 6 feeds material from the non-ferrous metals separator 5 into a primary buffer silo 7. The primary buffer silo 7 is connected to the air separator 9 by a closed conveyor 8. The air separator 9 is connected to the secondary preshredder 11 by a closed conveyor with pipe casing 10. Therefore, video and audio tapes are conveyed without the risk of causing damages to the conveyor system. The secondary preshredder 11 supplies further shredded plastic waste to the gravity separator 31 by a pneumatic conveyor 30. The gravity separator 31 feeds into a secondary buffer silo 50 by a chain conveyor with pipe casing 49. The agglomerate production device 52 is connected to the secondary buffer silo 50 by a chain conveyor with pipe casing 51 and to the secondary magnetic separator 84 by a bucket conveyor with pipe casing 85. Finally, a screening machine 86 receives material from the secondary magnetic separator 84 by a chute 89 of the secondary magnetic separator 84.

The secondary preshredder 11 is described in detail below with reference to Figure 2. The secondary preshredder 11 has a hopper 12 at the top of a casing 13. The hopper 12 is fed by the chain conveyor with pipe casing 10, see Figure 1. The inner space 22 of the casing 13 is equipped with a rotor 14, which carries knives 14a on its surface. The casing 13 is provided with a stationary knife 17 which is opposite the rotor 14. The casing 13 is equipped with an exhaust screen 16 spanning the space on the side of the pneumatic conveyor 30 in the inner space 22. The casing 13 is equipped with an ionized air generation room 15 upstream the rotor 14. The ionized air generation room 15 is provided with an earth electrode 18 and a discharge electrode 19. 20 stands for the ground. The earth electrode 18 and the discharge electrode 19 are connected with an alternating current source 21, these components are arranged to form an ionized air generator.

The gravity separator 31 is described in detail below with reference to Figure 3. The gravity separator 31 is equipped with a vibratile board 34 on the top of a casing 38 and with a hopper 32 above the board 34. The board 34 is slant in one direction indicated by the double arrow "X" and has penetrant holes 35 whose diameter is 1mm. An acceleration device 36 is connected to the vibratile board 34. The casing 38 is equipped with a fan 37 below the slant board 34 to generate vibration of the board 34 in X-direction. An earth electrode 39, a discharge electrode 40 and an

alternating current source 41, which are placed inside the casing 38, are arranged to form an ionized air generator. The alternating current source 41 is connected with the earth electrode 39 and the discharge electrode 40. 42 stands for the ground.

As shown in Figure 4, the agglomeration production device 52 is equipped with a disc compactor comprising a feeding unit 53 and a compacting unit 54. The feeding unit 53 is equipped with a buffer box 81 and a feeding screw 82 located at the lower part of the buffer box 81. Furthermore the agglomerate production device 52 comprises a postshredder 62 and an air separator 70. A chain conveyor with pipe casing 51 is connected to the buffer box 81 of the feeding unit 53. The feeding screw 82 precompacted the input material and conveys it to the compacting unit 54. A cooling water supply pipe 55 having a flow adjustment valve 56 is connected to the discs 54a, 54b of the compacting unit 54. A cooling water discharge pipe 57 is connected to discs 54 a, 54b of the compacting unit 54. The discs 54a, 54b of the compacting unit 54 are in a housing. The housing has an air inlet 58 and a discharging outlet 59 for sucking off the agglomerated material. A pneumatic conveying system for the compacting unit 54 is connected to a cyclone 60. The cyclone 60 feeds in to the postshredder 62 via a cellular wheel 61 for pressure decoupling. A water supply pipe 63 and air supply pipe 64 are connected to a set of spray nozzles 65 which sprays a water-air-mixture into the postshredder 62. A pneumatic conveyor 67 supplies material from the postshredder 62 to a cyclone 68. The cyclone 68 is connected to the air separator 70 via a cellular wheel 69. A chute 83 downstream the air separator 70 is connected to a bucket conveyor with pipe casing 85. The chute 83 downstream the air separator 70 is equipped with an impact scale 71. The air separator 70 is connected to a cyclone 73 by a pipe for feedback 72. The cyclone 73 is connected to the buffer box 81 via a cellular wheel 74. The cyclone 73 is provided with a pipe for discharge of air 76. The pipe for discharge of air 76 is equipped with a fan 75. The cyclone 60 is connected to the pipe for discharge of air 76 by a pipe for discharge of air 78 equipped with a fan 77. The cyclone 68 is connected to the pipe for discharge of air 76 by a pipe for discharge of air 80 equipped with a fan 79. It will be noticed that in the apparatus according to the preferred embodiment of the invention, there are three units consisting of a fan, a cyclone and a cellular wheel. The fan is, in every case, located downstream the cyclone, with regard to the airstream, whereas the cellular wheel is located downstream the cyclone, regarding the solid material flow. Since the cyclone separates all solid substances from the incoming flow, the fan is located always on the clean air side of the cyclone, with the advantages of practically no wear within the impeller and the housing of the fan, less noise and reduce energy consumption, as compared to an arrangement of the prior art.

The method for treatment of plastic waste is described with reference to the preferred embodiment of the apparatus for treatment of plastic waste shown in Figures 1 to 4.
The plastic waste exhausted by each household and building is fed to the primary preshredder 1. The plastic waste comprises various kinds of plastics with full variety in their shape.
Generally the plastic waste includes impurities such as e.g. metals, glasses, plasters, clothes, papers. Some of the foreign substances are bound to plastic materials. The various kinds of plastics include e.g. PP(Polypropylene), PE(Polyethylene), PS(Polystyrene), PET(Polyethylene Terephthalate), and also a proportion of PVC (Polyvinylchloride).

A typical composition of Japanese plastic waste is given in the Table below:

Table: The composition of Japanese waste plastics

	%
PP + PE	26.3
EPS	13.3
PS + ABS	17.9
PET	8.8
PVC + PVDC	7.3
video cassettes and audio cassettes	0.5 – 1.5
other plastics	10.0
Papers	4.5
Metals	3.5 – 4.5
bag for collection	7.0
Total	100

The plastic waste is shredded within the primary preshredder 1 so that the plastic waste can be reduced below a certain size suitable for removing the foreign substances with the primary magnetic separator 3, non-ferrous metals separator 5 and air separator 9. The primary preshredder 1 is a mono-axial type shredder. The plastic waste is fed inside the primary preshredder 1 through a feeding hopper located on the top side of the primary shredder 1, and pushed on rotary knives attached to a rotor with a pusher (for example, a ram). The plastic waste comes into a gap space in which rotary knives are opposite a stationary knife and, as a result the plastic waste is shredded. The primary preshredder 1 is equipped with an exhaust screen with 50 mm diameter openings below the rotor. The plastic waste is shredded inside the primary preshredder 1 over and over again to the extent that the size of plastic waste becomes small enough to pass through the

openings, i.e. now consists of particles having a size of less than 50 mm. Owing to friction heat generated in this shredding process, part of moisture in the plastic waste evaporates inside the primary preshredder 1, and the plastic waste is dried to some extent, which drying, however, cannot be controlled.

The shredded plastic waste discharged from the primary preshredder 1 which contains also full-length tapes on their reels is conveyed to the primary magnetic separator 3 by the closed conveyor 2, and discharged to the non-ferrous metals separator 5 via the chute 4 of the primary magnetic separator 3. During the transport of the plastic waste from the primary preshredder 1 to the non-ferrous metals separator 5, ferrous metals such as e.g. iron included in the plastic waste are removed from the plastic waste with the primary magnetic separator 3. An overbelt magnet separator and a drum magnet separator are used as the primary magnetic separator 3. The overbelt magnet separator placed over the conveyor belt 2 has an excellent throughput capacity, but fails to remove fine metal pieces. The drum magnet separator is placed at the end of the conveyor belt 2 downstream the overbelt magnet in order to remove the fine ferrous pieces. The plastic waste enters the drum magnet separator, and leaves from the chute 4 of the drum magnetic separator to the non-ferrous metals separator 5.

The non-ferrous metals separator 5 removes non-ferrous metals such as e.g. aluminium and copper from the plastic waste. An eddy current separator is used as the non-ferrous metals separator 5. The plastic waste discharged from the non-ferrous metals separator 5 is conveyed to the primary buffer silo 7 by the closed conveyor 6. The primary buffer silo 7 is placed so that the machines upstream the primary buffer silo 7 (primary preshredder 1, primary magnetic separator 3 and non-ferrous metals separator 5) may continue to work without shutdown for a certain term, i.e. until the primary buffer silo 7 is filled with plastic waste, when one or some of the machines downstream the primary buffer silo 7 (e.g. secondary preshredder 11) have stopped.

The plastic waste is conveyed from the primary buffer silo 7 to the air separator 9 with the closed conveyor 8. The air separator 9 removes non-metal foreign substances such as e.g. glass, plaster, from the plastic waste. Foreign substances such as e.g. paper and cloth, if they are wet, are removed as a heavy weight fraction together with heavy non-metal foreign substances such as e.g. glass, plaster. On the other hand the foreign substances such as e.g. paper, cloth remain as a light weight fraction in the stream of plastic waste if their moisture content is low. A stream of dry air which the plastic waste is exposed to inside the air separator 9 makes progress on the drying of

plastic waste. Most of foreign substances included in the plastic waste are removed with the primary magnetic separator 3, non-ferrous metals separator 5 and air separator 9. Since those substances which might damage shredder knives and impair the functioning of shredder are removed from the plastic waste, the plastic waste may be now shredded into smaller pieces. This shredding is performed with the secondary preshredder 11.

The plastic waste from which the foreign substances have been removed by the air separator 9 is fed into the hopper 12 of the secondary preshredder 11 by the closed conveyor 10. As shown in Figure 2, the plastic waste includes plastics free of chlorine 23 and chlorine-containing plastics 24. The plastic waste is fed to inner space 22, and shredded into smaller pieces with knives 14a attached to a rotor 14 which is rotating and a stationary knife 17. The secondary preshredder 11 is a mono-axial shredder, too, and is equipped with an exhaust screen 16 with 10 mm diameter openings below the rotor. The plastics 23 and PVC 24 are shredded over and over again to the extent that the size of plastic waste becomes small enough to pass through the openings (less than 20 mm, preferably less than 10 mm). Plastics 27 and PVC 28 which have passed through the openings are discharged to a pneumatic conveyor 30. The size of the plastic waste fed to the hopper 12 of the secondary preshredder 11 is less than 50 mm in diameter, and hence the plastic waste is fluffy. For this reason, air in the inner space 22 is sucked with a fan (not shown in Figure 2) connected to the pneumatic conveyor 30 via a cyclone (not shown in Figures) so that the plastic waste may be successfully fed from the hopper 12 to the inner space 22 and discharged through the exhaust screen 16. The plastic waste conveyed with the pneumatic conveyor 30 and then separated from air with the cyclone is conveyed to a hopper 32 of the gravity separator 31 via a cellular wheel (not shown in Figures). The connection condition of the fan, cyclone, cellular wheel not shown in Figures and the pneumatic conveyor 30 is the same to the connection condition of the fan 77, cyclone 60, cellular wheel 61 and pneumatic conveyor 59.

The high voltage is generated between the earth electrode 18 and the discharge electrode 19 located in the ionized air generation room 15 with the alternating current source 21, and alternating corona discharge is generated between the earth electrode 18 and the discharge electrode 19. As a result, and the ionized air is fed into the inner space 22. Hence the electrified plastic waste in the inner space 22 is neutralized with the ionized air and the plastic waste is protected from sticking one another due to electricity.

The main components of plastics useful for recycle in the domestic plastic waste are the plastics free of chlorine are such as e.g. PP, PE, PS, PET etc. as described above. The specific gravities of PP, PE, PS, PET are 0.90-0.95, 0.92-0.98, 1.02-1.10 and 1.30-1.40, respectively. The specific gravity of another main component, EPS(Expanded Polystyrene) is fairly lower than the specific gravity of PS. On the other hand, the specific gravity of PVC which should be removed from the plastic waste is 1.25-1.45, so that a gravity separation from all materials except PET is possible. Several methods of sorting out PET are known, such as that disclosed in JP 09 299 828 A. Part of the PET tape portions which remain in the waste and sorted out with PVC.

The gravity separator 31 is a device for removing a kind of plastics, PVC, by making use of the difference in specific gravities. The plastics 27 and PVC 28 inside the hopper 32 are fed on the slant vibratile board 34. A high voltage is generated between the earth electrode 39 and the discharge electrode 40 with the alternating current source 41, and alternating corona discharge is generated between the earth electrode 39 and the discharge electrode 40. As a result, positive ions 44 and negative ions 45 are generated alternatively. Because the fan 37 is working, the ionized air including positive ions 44 and negative ions 45 flows and the upward streams of ionized air 43 pass through the holes 35 above the vibratile board 34. Owing to the upward streams 43 through the holes, PP, PE, PS and EPS etc. of the plastics 27 whose specific gravities are lower move to form an upper layer, while PVC 28 and PET, if still present, of the plastics 27 whose specific gravities are higher move to the lower layer. Then, owing to the X-direction component of vibration which is a slope direction of the slant board 34 occurring with the driving of the acceleration device 36, PVC 28 and PET in the lower layer are exposed to the upward force in the slope direction and gradually go up along the slope of the board 34. Finally, PVC 28 and PET reach the upper edge of the board 34, and drop into the collection box 46. On the other hand, the plastics useful for recycle in the upper layer whose specific gravities are lower are pushed aside by PVC 28 and PET, and gradually go down along the slope of the vibratile board 34, and finally reach the chain conveyor with pipe casing 49. The wind velocity of the upward streams of ionized air 43 is adjusted to the extent that the plastic waste of higher specific gravity in the lower layer is not blown off. On the other hand the air flow enhances the formation of two layers, one of material with higher specific gravity and one of material with lower specific gravity.

Even if the plastic waste on the vibratile board 34 may be electrified due to their mutual friction, the electrified plastic waste is immediately neutralized with either of the positive or negative ions owing to the contact of the electrified plastic waste with the upward streams of ionized air 43

including the positive ions 44 and the negative ions 45. As a result the plastic waste on the vibratile board 34 is protected from sticking one another due to electricity, which is in particular important for processing films.

The ionized air generator comprising the earth electrode 39, the discharge electrode 40 and the alternating current source 41 may be placed near and below the vibratile board 34, because the positive ions 44 and negative ions 45 are attracted to the electrified plastic waste on the vibratile board 34 by Coulomb force if only the ionized air generator is placed near the board 34.

In the embodiment of the invention, the plastic waste has been shredded with the secondary preshredder 11 to the extent that the size of the plastic waste is preferably smaller than 10 mm in diameter, and hence the size heterogeneity and the effect of the size decrease in the separation process of PVC 28 (and PET) due to vibration of the slant board 34. If the plastic waste is shredded only with the primary preshredder 1 and without the secondary preshredder 11 as shown in EP 0 800 445 A1, the plastic waste can not be shredded to the extent that the size of plastic waste becomes smaller than 10 mm in diameter because of the damage of the knives of the primary preshredder 1 due to the possible metal impurities included in the plastic waste. If the size of the plastic waste is large, the effect of the size is significant and the effect of the difference in the specific gravities will vanish because of the effect of the size. This is in particular important if a considerable amount of film-like plastic material is present. Hence if the size of the plastic waste is large, the separation efficiency of PVC 28 will be low in the separation process making use of the differences in specific gravity. If the maximum size of the plastic waste is 50 mm, the size heterogeneity will also give rise to the decrease of the separation efficiency of PVC 28. But if the size of the plastic waste is small as in the embodiment of the invention, the effect of the differences in specific gravity will become relatively large and the separation efficiency of PVC 28 and PET making use of the differences in specific gravity will be improved remarkably. In other words, if the fine plastic waste shredded with the secondary preshredder 11 is fed to the gravity separator 31, the content of the plastics of lower specific gravity useful for recycle such as e.g. PP, PE, PS and EPS etc. included in PVC 28 and PET in the collection box 46 will decrease. Inversely, the content of PVC 28 included in the plastic waste discharged to the chain conveyor with pipe casing 28 will decrease. The effects mentioned above become very large in co-operation with the improvement of the separation efficiency by making use of ionized air. The upward streams of ionized air 43 through the holes 35 of the vibratile board 34 also contribute to the improvement of the separation efficiency of the plastics whose specific gravity is high. Be-

cause the gravity separator 31 is placed upstream the agglomerate production device 52, especially upstream the disc compactor, the content of chlorine included in granular agglomerate produced will decrease remarkably. This will give rise to the remarkable decrease of the possibility of corrosion due to chlorine in a blast furnace facility when the granular agglomerate is recycled as reducing agent in the blast furnace. Further, the production of dioxine and furanes within the blast furnace is prevented.

By beforehand removing PET bottles from the plastic waste, for instance collecting PET bottles and the other plastic waste separately, before the plastic waste is supplied to the embodiment of the invention of the apparatus for treatment of plastic waste, the separation efficiency of the chlorine-containing plastics from the plastics free of chlorine with the gravity separator 31 is especially improved because PET bottles useful recycle are not removed together with PVC. When the yield of the plastics free of chlorine is about 75 %, about 60 % of the chlorine-containing plastics can be removed. Because the PVC content of Japanese domestic plastic waste is less than about 80 %, the PVC content and the chlorine content of the granular agglomerate produced will become less than 3.2 % and 1.6 %, respectively, by removing about 60 % of the chlorine-containing plastics. By beforehand removing PET bottles, PET material can be recycled effectively.

The plastic waste discharged to the chain conveyor with pipe casing 49 is conveyed to the secondary buffer silo 50. The secondary buffer silo 50 is placed for the same aim as the primary buffer silo 7 so that the machines upstream the secondary buffer silo 50 may continue to work without shutdown for a certain term when one or some of the machines downstream the secondary buffer silo 50 have stopped. Furthermore, the secondary buffer silo 50 helps to homogenize the plastic waste and therefore prevents the maldistribution of a certain kind of plastics by circulating. As a result the composition of the plastic waste fed from the secondary buffer silo 50 to the agglomerate production device 52 does not vary significantly with time. Hence the composition of the granular agglomerate produced does not vary significantly with time, either.

The agglomerate production device 52 converts the heterogeneous input material into the granular agglomerate that is homogeneous, porous, compact and granular material with a density in excess of 320 kg/m^3 up to 530 kg/m^3. The granular agglomerate can be used for various industrial purposes. For instance, the granular agglomerate can be used as a substitute for heavy oil or coke, namely as reducing agent, in the blast furnace. In the compacting unit 54 of the agglomer-

ate production device 52, the plastic waste undergoes rapid heating due to friction. The temperature of the plastic waste is controlled not to reach melting temperature, as explained below. The plastic particles are merely softened to a temperature slightly below the melting temperature. The melting temperature strongly depends on the composition of the plastic waste, and hence the plastic waste should be homogenized in the secondary buffer silo 50 as described above.

The plastic waste in the secondary buffer silo 50 is conveyed into the buffer box 81 which is part of the feeding unit 53 of the agglomerate production device 52 by the chain conveyor with pipe casing 51. A feeding screw 82 at the bottom of the buffer box 81 carries the plastic waste in the buffer box 81 into a central channel formed by a pair of discs 54a, 54b of the compacting unit 54. Inside the buffer box 81 there are paddle screws(not shown in Figures) whose rotation prevents arching and helps ensure that the plastic waste is drawn in by the feeding screw 82.

One of the two discs 54a, 54b in the compact unit 54 is driven by a motor (not shown in Figures). Through the rotation of the one disc 54b, the plastic waste existing between the two discs is forced into a spiral, exposed to friction energy, rapidly heated as a result, and drawn into "noodle", namely converted into the agglomerate. During the compacting process, the residual metal pieces, such as e.g. springs of spray caps, metal tags of plastic nets and metal chips becoming tangled with films, are separated by being subjected to extreme mechanical forces and heat. Both discs 54a, 54b are independently cooled by water supplied by line 55 through a valve 56 which is controlled by a controller 87, as explained further below. The cooling water exits the unit through line 57.

If the residual dampness is greater than 6 wt. %, friction energy is used only for drying the plastic waste and the plastic waste can not be agglomerated (compacted) efficiently. According to the embodiment of the invention, the plastic waste is partly dried during each process in the primary preshredder 1, air separator 9, secondary preshredder 11, and gravity separator 31 upstream the agglomerate production device 52. Furthermore, the embodiment of the invention needs no wet processing steps upstream the agglomerate production device 52. Hence the residual dampness of the plastic waste entering the disc compactor is less than 6 wt. % and the plastic waste is successfully agglomerated if only the plastic waste supplied to the embodiment of the invention has been stored inside not to be exposed to rain water.

The fan 77 generates an air stream from the air inlet 58 of the housing of the discs of the compacting unit to the cyclone 60. The agglomerate, together with the foreign substances such as e.g. the above mentioned residual metal pieces, cloth, light weight substances (for instance, dried paper, glass fiber) and steam generated during the compacting process is radially ejected from between the pair of discs into the pneumatic conveyor 59 and sucked off with the help of the above-mentioned air stream. When the agglomerate, residual metal pieces, cloth, light weight substances and steam reach the cyclone 60, the air passes into the pipe for air discharge 76 via the pipe for air discharge 78. The solid materials, even scatterable obstructive substances such as the like weight substances, and fluffy uncompacted materials, which have been separated from the air stream by the cyclone 60 pass through the cellular wheel 61 into the postshredder 62. The agglomerate discharged from the compacting unit 54 is dried by the contact with air during the transport step in the pneumatic conveyor 59.

The fan 77 works as a device for generating the air stream helping to convey the agglomerate. The cyclone 60 is a device for separating the agglomerate and the scatterable substances from the air for conveying. The installation of the cyclone 60 makes possible to extract the scatterable substances and agglomerate from the compacting unit 54 and then convey the scatterable substances and agglomerate together. Because the scatterable substances and agglomerate are conveyed with one conveyor, the structure of the agglomerate production device 52 can be simplified. The cyclone 68 described below is a device for separating the granular agglomerate from the air for conveying, and the cyclone 73 is for separating unagglomerated or fluffy uncompacted plastics from the air for conveying. The fans 75 and 79 are devices for generating air stream for conveying.

The transport speed of agglomerate is slowed down to a certain level with the cellular wheel 61. Hence the temperature of the agglomerate fed through the cellular wheel 61 can be measured effectively and directly with an infra-red thermo-sensor 66 between the cellular wheel 61 and the postshredder 62. The temperature is measured indirectly with a sensor accommodated within the stationary disc 54a in the compactor, and such sensor, for example a resistance thermometer, can be provided additionally, if desired. The measured value of the temperature with the thermo-sensor 66 is transmitted to the controller 87, and the controller 87 automatically transmits on or off signal to the solenoid valve 56 for keeping the temperature below the melting temperature of the plastic waste. Although not shown in Figures, the two discs 54a, 54b of disc compactor 53, 54 have a pass for cooling water inside, respectively. When the measured value of temperature

becomes higher than a certain maximum setting value, the solenoid valve 56 automatically opens according to on signal from the controller 87 and cooling water starts flowing in the passes. On the other hand, when the measured value of temperature becomes lower than a certain minimum setting value, the solenoid valve 56 automatically closes according to off signal from the controller 87 and the cooling water stops flowing in the passes. Because the two discs 54a, 54b are cooled like this, in the compacting unit 54 the plastic waste is merely softened to a temperature slightly below the melting temperature.

The basic structure of the postshredder 62 is practically same to the secondary preshredder 11 described above. The postshredder 62 is equipped with an exhaust screen with 8 mm diameter openings, and the agglomerate is shredded over and over again to the extent that the size of the agglomerate becomes small enough to pass through the openings (less than 8 mm in diameter). The temperature of the agglomerate should be decreased so that the agglomerate may be shredded with ease. The water injected into the spray nozzle 64 from the water supply pipe 63 turns into fine waterdrops owing to the air injected into the spray nozzle 64 from the air supply pipe 63, and the fine waterdrops spray on the space above the rotor in the postshredder 62. The agglomerate fed into the postshredder 62 contacts the waterdrops and are cooled, and then the agglomerate is shredded with the rotor to turn into the granular agglomerate. The waterdrops completely vaporize to turn into steam owing to heat from the agglomerate.

The granular agglomerate and steam discharged from the postshredder 62 are conveyed towards the cyclone 68 with air stream inside the pneumatic conveyor. The air stream is generated with the drive of the fan 79. The air and steam are separated with the cyclone 68 and discharged to the pipe for discharge of 80. The granular agglomerate which has passed through the cyclone 68 is conveyed to the air separator 70 with the cellular wheel 69. The fluffy uncompacted lightweight substances such as films and fines which have failed to be agglomerated and conveyed with the granular agglomerate are separated with the air separator 70. The separated unagglomerated substances are conveyed to the cyclone 73 via the pipe for feedback 72 owing to the drive of the fan 75. The air is separated with the cyclone 73 and discharged to the pipe for discharge of air 76. The fluffy uncompacted substances separated with the cyclone 73 are fed back to the buffer box 81 of the feeding unit 53 with the cellular wheel 74. The fluffy uncompacted substances are fed to the compacting unit 54 and agglomerated together with the plastic waste from the chain conveyor with pipe casing 51. In the period immediately after starting up the disc compactor, the discs of the compacting unit 54 are cold, and the content of unagglomerated lightweight sub-

stances is high. Hence the re-agglomeration process for agglomerating again the unagglomerated substances separated with the air separator 70 and fed back to the disc compactor due to the feedback device for the unagglomerated substances comprising the air separator 70, the pipe for feedback 72, the cyclone 73 and the cellular wheel 74 is very important especially in the period immediately after starting up in order to prevent the undesired unagglomerated substances from mixing with the granular agglomerate. Because the unagglomerated substances are separated after removing the scatterable substances in the agglomeration production device 52, the scatterable substances are not fed back to the compacting unit 54 and hence the re-agglomerated agglomerate is prevented from mixing with the scatterable substances.

The granular agglomerate separated from the unagglomerated substances with the air separator 70 passes down to the impact scale 71 for measuring the mass flow rate of the granular agglomerate, and then discharged from the agglomerate production device 52 via the chute 89. The granular agglomerate is conveyed to the secondary magnetic separator 84 by the bucket conveyor with pipe casing 85, and separated from the ferrous metal pieces such as iron pieces included in the granular agglomerate. Only a drum magnet is used as the secondary magnetic separator 84. The granular agglomerate free of ferrous metal pieces and magnetic tape material is conveyed to the screening machine 86 via the chute 89 of the secondary magnetic separator 84.

Because the steam generated by contact of the waterdrops with the agglomerate in the postshredder 62 is completely removed with the cyclone 68, the residual moisture content of the granular agglomerate leaving the agglomerate production device 52 and conveyed to the screening machine 86 is less than 1 %. The waste air streaming inside the pipe for discharge of air 76 and including the scatterable substances is discharged to the atmosphere after purified with a dust filter and a deodorizer not shown in Figures.

The measured value of mass flow rate of the granular agglomerate measured with the impact scale 71 is transmitted to the controller 88. The controller 88 automatically controls the rotation speed of the feeding screw 82 so as to keep the mass flow rate close to a certain setting value. As a result the mass flow rate of the plastic waste fed to the compacting unit 54 can be adequately adjusted, and hence the production rate of the granular agglomerate can be kept nearly constant. The rotation speed of the feeding screw 82 may be manually controlled so as to change the production rate of the granular agglomerate.

In the agglomerate production device the fans 75, 77 and 79 which generate the air stream are located not upstream but downstream the cyclones 73, 60 and 68, respectively. The advantage of the special feature that each fan is located downstream each cyclone is that the agglomerate, the granular agglomerate or the unagglomerated substances do not come into contact with the fan's impellers. This results in far less wear of the impellers and much lower sound power level comparing to a material side location. Moreover this results in less energy consumption of the fan motor. The unfavourable material side location means that the solid material is conveyed through the housing and the impeller of the fan.

The hole size of the screen of the screening machine 86 is about 10 mm. The shape-flexible substances such as e.g. cloth pieces remaining in the granular agglomerate are removed with the screening machine 86. The secondary preshredder 11 and the postshredder 62 are equipped with the exhaust screens with 10 mm and 8 mm diameter openings, respectively. But the plastic waste and the granular plastics are discharged by sucking off with the fans, and hence the shape-flexible substances such as e.g. cloth pieces pass through the openings even if the size of the shape-flexible substances at the normal condition without sucking off is larger than the diameter of the openings. The screening machine 86 is useful for removing such shape-flexible substances. The granular agglomerate discharged from the screening machine 86 is a product to be recycled as the reducing agent for the blast furnace etc.

According to the embodiment of the invention, the granular agglomerate of high quality (Foreign impurities content: less than 10 weight%, Specific gravity: higher than 0.3, Chlorine content: less than 2 weight %, Moisture content: less than 1 weight %, Grain size: less than 10 mm) can be produced because the removal efficiency of the chlorine-containing plastics is improved. The granular agglomerate of high quality can be used in various recycling techniques. For instance the granular agglomerate can be used as a substitute for heavy oil and coke in the blast furnace as described above.

Claims

1. A dry treatment method for plastic waste containing plastic materials of different specific gravity and of different shape, in particular containing a proportion of flat and/or band-like film materials, comprising:

a) a first shredding step of shredding a mass of plastic waste;

b) a metal separating step of separating metal materials from said plastic waste thus shredded;

c) a second shredding step of shredding said plastic waste from which said metal materials have been separated down to a size of not more than 20 mm;

characterized in that the plastic waste is conveyed from step a) to step b) and from steb b) to step c) with conveying systems in which rotating components are encapsulated against their environment, and

further characterized by

e) an agglomerating step of thermally agglomerating said plastic waste thus obtained, where said plastic waste is mechanically precompacted substantially without increasing its temperature prior to the thermal agglomeration; and

f) a second metal separating step of separating metallized or magnetized film or band-like materials which have not been agglomerated.

2. A method according to claim 1, characterized by

d) a plastic separating step of separating chlorine-containing plastic materials from said plastic waste shredded in step c) by making use of differences in specific gravity among said plastic materials contained in said plastic waste.

3. A method according to claim 2, characterized in that step d) comprises the steps of:

supplying said plastic waste on a slant board (34);

supplying air to said plastic waste through a plurality of penetrant holes (35) provided in said board (34) in the direction from under to over of said board with a velocity and volume rate that said chlorine-containing plastic materials (48) accumulate in a layer adjacent said slant board (34) and plastic materials (47) having lower specific gravity than said chlorine containing materials accumulate in a layer floating on said layer of chlorine-containing materials; and

applying, in such a state, a vibration exciting force to said board (34) to convey said chlorine-containing materials (48) into a direction substantially upward said slant board (34) and to convey said layer of plastic materials (47) having lower specific gravity into a direction substantially downward said slant board (34).

4. A method according to claim 2, wherein step (d) comprises the step of:

bringing ionized air (44, 45) into contact with said plastic waste.

5. A method according to one of claims 1 to 4, characterized by

g) separating uncompacted materials from a flow of agglomerated materials obtained by agglomerating said plastic waste; and

agglomerating said uncompacted materials thus separated together with said plastic waste which has been shredded in step c) and/or from which said chlorine-containing plastic materials have been separated,

where step g) is performed after step e) or after step f).

6. A method according to one of claims 1 to 5, further comprising the step of:

h) further shredding said agglomerated material during cooling said agglomerated material with a mixture of air and water by evaporation the water after having contact with the agglomerated material.

7. A plastic waste dry treatment apparatus for plastic waste containing plastic materials of different specific gravity and different shape, in particular containing a proportion of flat and/or band-like film materials, comprising:

a first shredder (1) for shredding a mass of plastic waste;

a metal separator (3, 5) for separating metal materials from said plastic waste shredded by said first shredder;

a second shredder (11) for shredding said plastic waste from which said metal materials have been separated;

characterized in that a conveyor system (2; 4, 6, 8, 10) is provided between said first shredder (1) and said metal separator (3, 5) and between said metal separator (3, 5) and said second shredder (11), said conveyor system (2; 4, 6, 8, 10) consisting of conveyor means in which rotating components are encapsulated against their environment; and

further comprising

an agglomerator device (52) comprising a mechanical precompactor (54c) in which said plastic waste is densified substantially without increasing its temperature before being agglomerated; and

a second metal separator for separating metallized or magnetized film materials which have not been agglomerated.

8. An apparatus according to claim 7, characterized by a plastic separating device (31) for separating chlorine-containing plastic materials from said plastic waste shredded by said second shredder (11) on the basis of differences in specific gravity among said plastic materials contained in said plastic waste.

9. An apparatus according to claim 8, characterized in that

said plastic separating device (31) for separating said chlorine-containing plastic materials on the basis of differences in specific gravity among said plastic materials comprises:

a board (34) having a plurality of penetrant holes (35) and slantly disposed, to the upper surface of which said plastic waste is to be supplied;

a vibration exciter (36) for applying a vibration exciting force to said board (34) to convey said chlorine-containing materials (48) into a direction substantially upward said slant board (34) and to convey said layer of plastic materials (47) having lower specific gravity into a direction substantially downward said slant board (34); and

an air generator (37) to supply air to the plastic waste through a plurality of penetrant holes (35) provided in said board (34) in the direction from under to over of said board with a velocity and volume rate that said chlorine-containing plastic materials (48) accumulate in a layer adjacent said slant board (34) and plastic materials (47) having lower specific gravity than said chlorine-containing materials accumulate in a layer floating on said layer of chlorine-containing materials.

10. An apparatus according to claim 8 or 9, wherein said plastic separating device (31) comprises an ionized air generator (39, 40, 41) for generating ionized air (43) to be in contact with said plastic waste.

11. An apparatus according to any of claims 7 to 10, further comprising:

an uncompacted material separating device for separating uncompacted materials from agglomerated materials discharged from said agglomerating device; and

a supplying device for feeding said uncompacted materials separated by said uncompacted material separating device to said agglomerating device.

12. An apparatus according to any of claims 7 to 11, characterized in that the plastic waste from the agglomeration device (54) is conveyed by an underpressure into a cyclone device (60,

68, 74), where the underpressure generating device (77, 79, 75) is located on the clean air side of the cyclone device (60, 68, 74).

13. An apparatus according to claim 7, further comprising:

a third shredder (62) for shredding agglomerated material discharged from said agglomerating device (54); and

a cooling water supplying device (65), communicated to said third shredder (62), for cooling said agglomerate during shredding by evaporating the water after having contact with the agglomerated material.

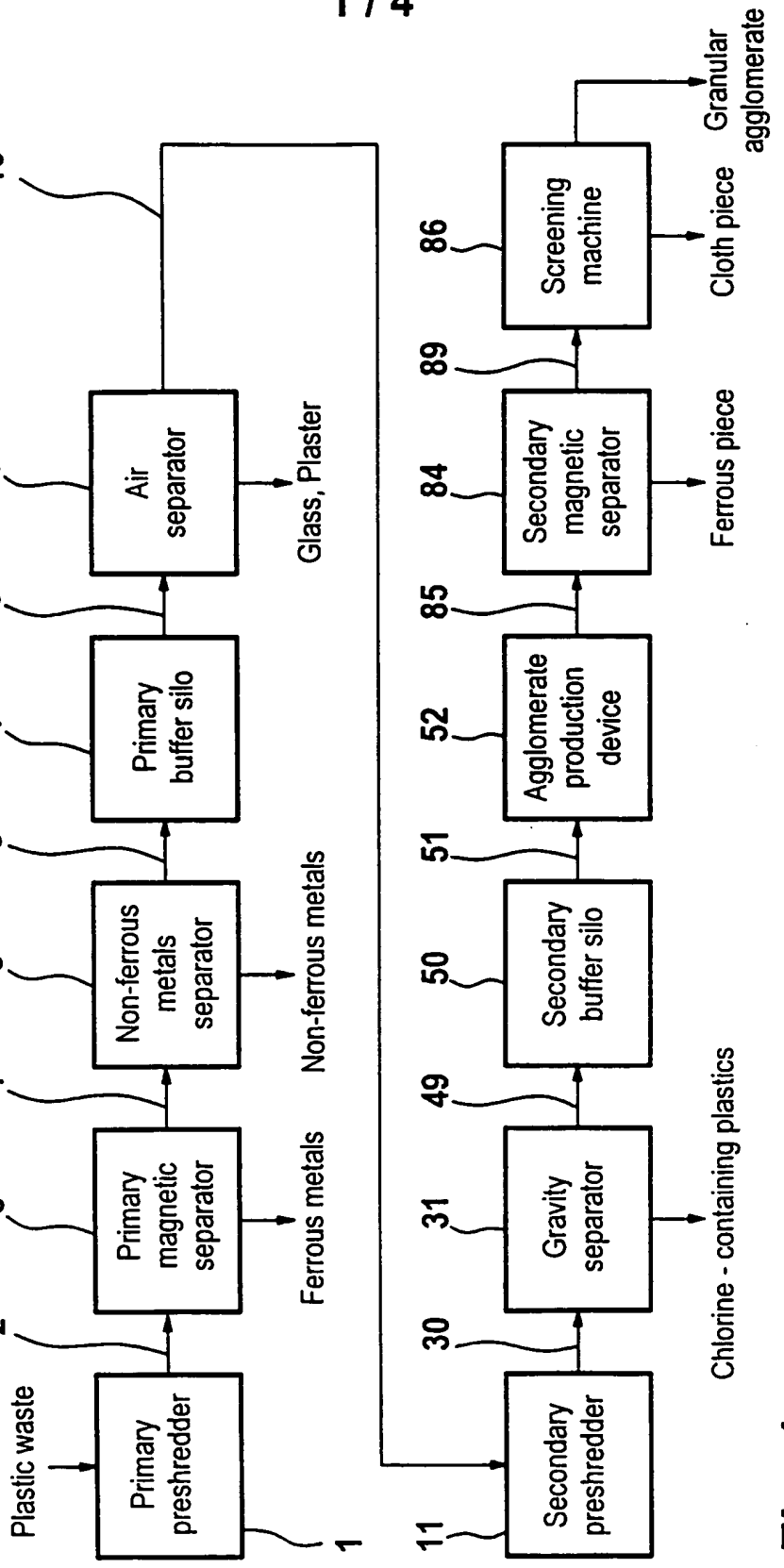
Plastic waste
Primary preshredder
2
Primary magnetic separator
3
Ferrous metals
4
Non-ferrous metals separator
5
Non-ferrous metals
6
Primary buffer silo
7
8
Air separator
9
Glass, Plaster
10
1
11
Secondary preshredder
30
Gravity separator
31
Chlorine - containing plastics
49
Secondary buffer silo
50
51
Agglomerate production device
52
85
Secondary magnetic separator
84
Ferrous piece
89
Screening machine
86
Cloth piece
Granular agglomerate

Fig. 1

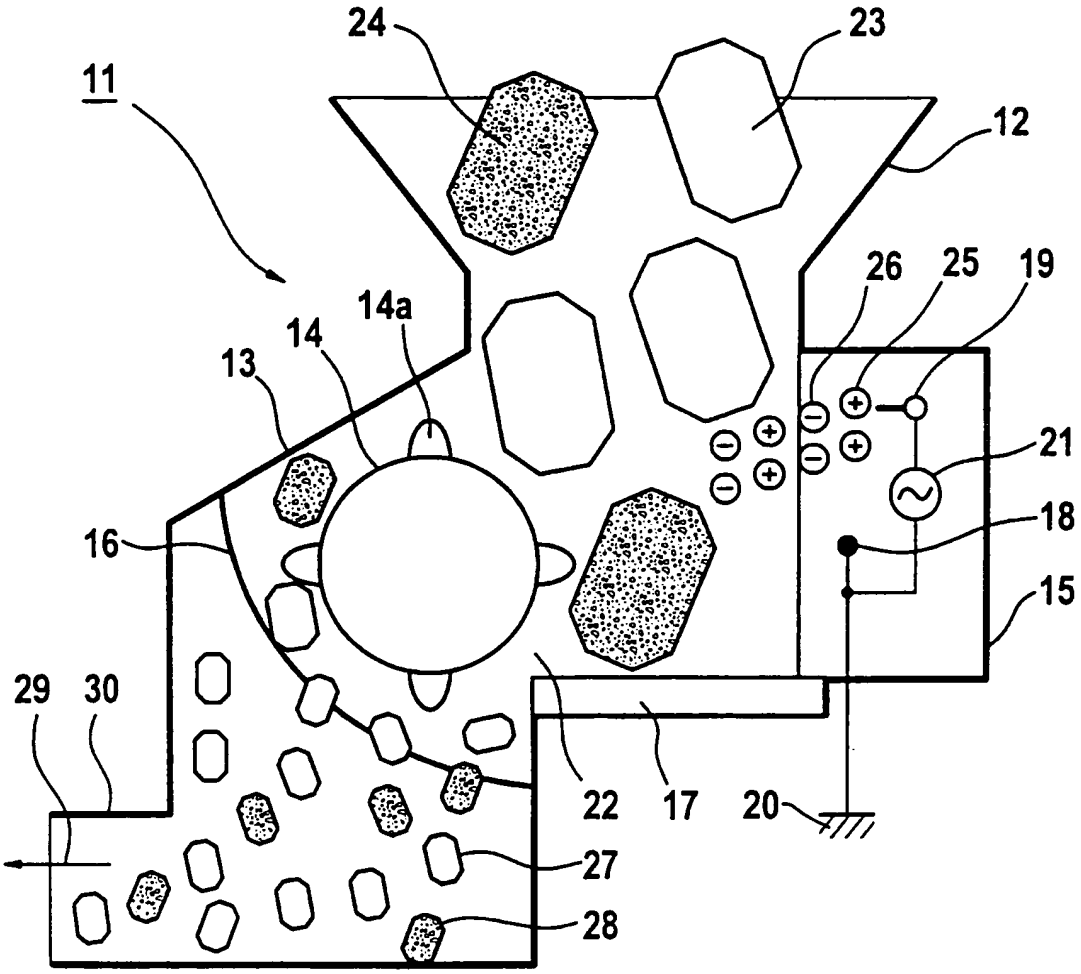

Fig. 2

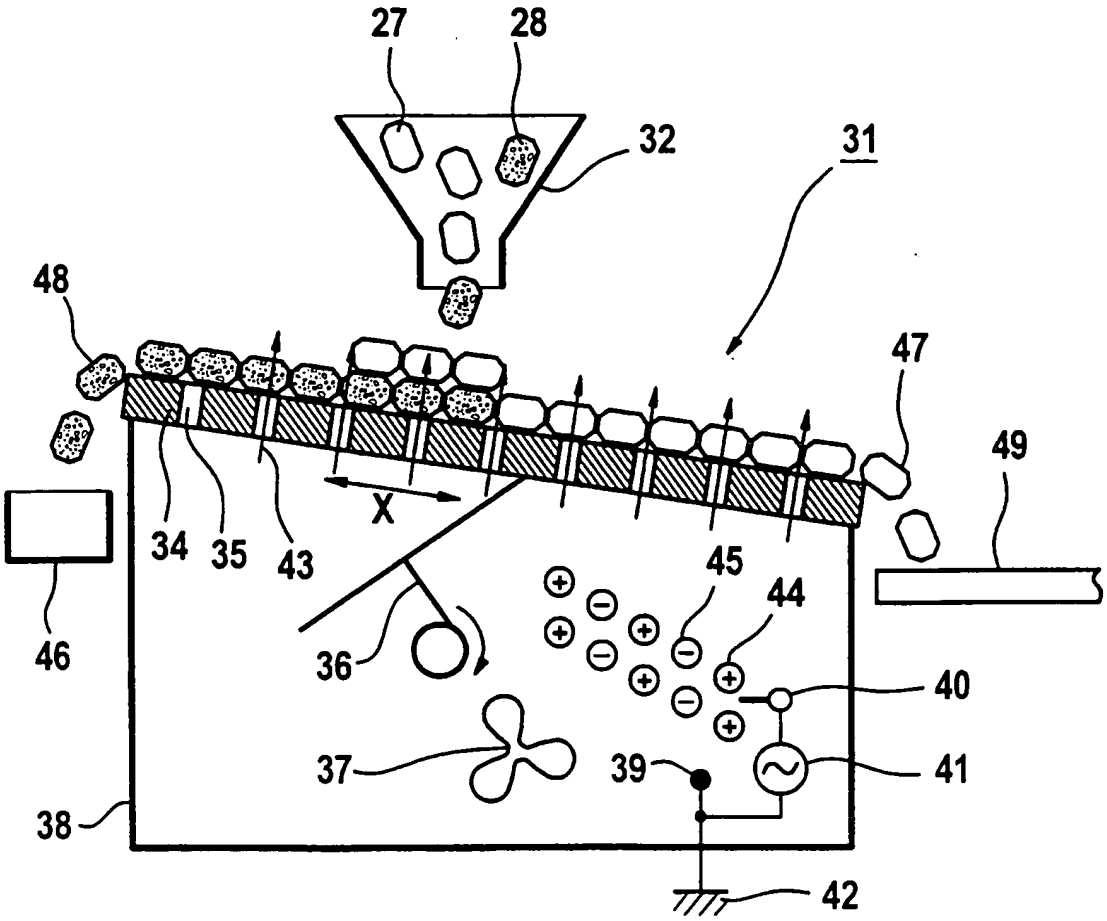

Fig. 3

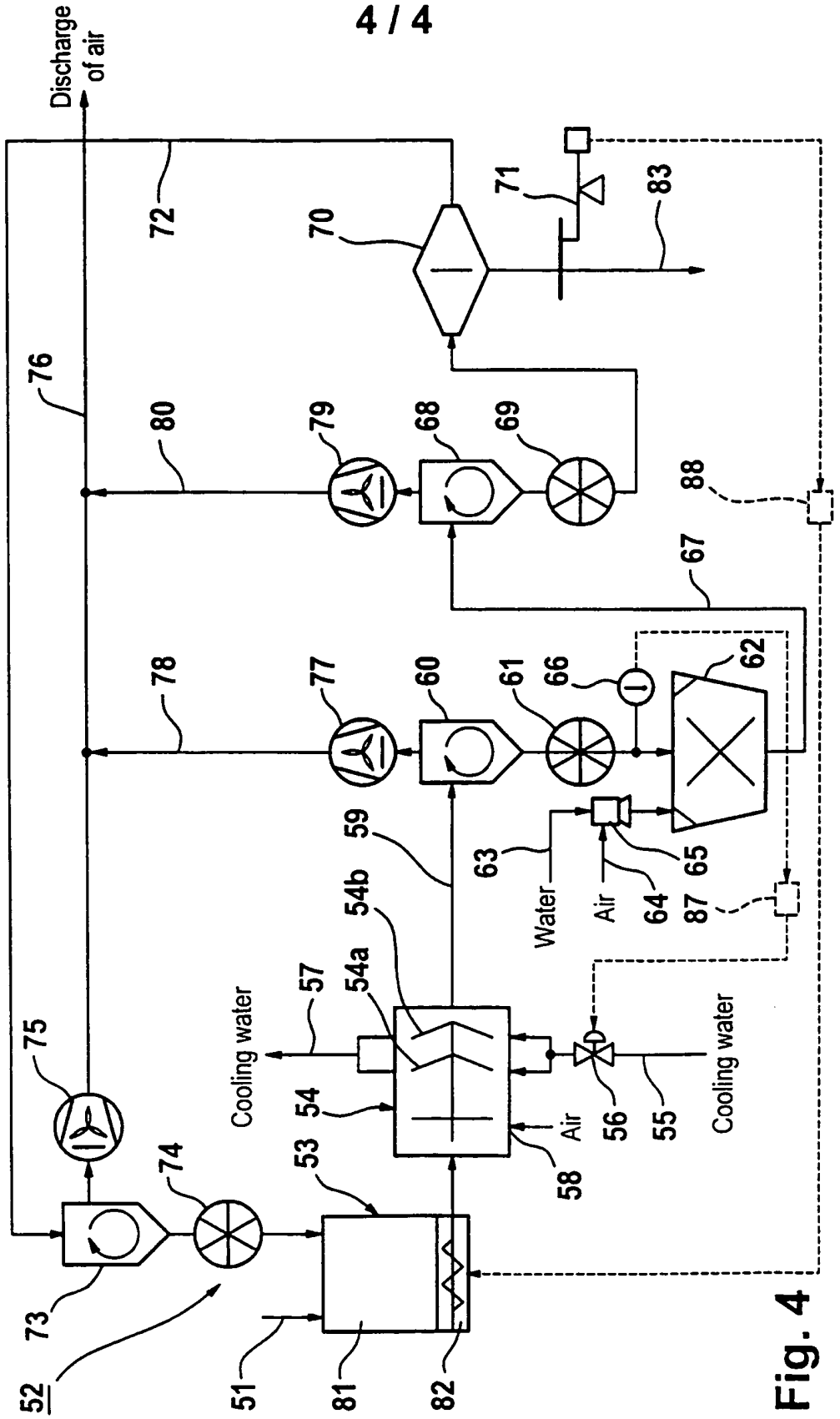
Discharge of air
72
70
71
83
76
80
79
68
69
88
67
78
77
60
61
66
62
59
63
Water
Air
64
65
87
54b
54a
57
Cooling water
75
54
Air
56
55
Cooling water
53
58
74
73
52
51
81
82

Fig. 4

INTERNATIONAL SEARCH REPORT

Inter nal Application
PCT/EP 99/0649[illegible]

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B29B17/02 B29B17/00 B03B9/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B29B B03B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 522 554 A (BLANK REINHARD A ET AL) 4 June 1996 (1996-06-04) cited in the application column 2, line 10-53; figure 1	1-13
A	WO 96 20819 A (GUSCHALL DIETMAR ;GUSCHALL HEINER (DE); HELMERTH AXEL (DE); HIMMEL) 11 July 1996 (1996-07-11) cited in the application page 1-13; figure 2	1-13
A	US 5 630 553 A (SERBAN PETRE ET AL) 20 May 1997 (1997-05-20) figure 1	1-13
A	US 5 184 780 A (WIENS THOMAS J) 9 February 1993 (1993-02-09) figure 1	1-13

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
2 May 2000	15/05/2000

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